Design and Realization of an Intelligent Composite-switch

Xuexing Wu[*1], Shuguang Liu[2]

School of Electronic and Information Eng. Xi'an Polytechnic UniversityXi'an, China

School of Electronic and Information Eng. Xi'an Polytechnic UniversityXi'an, China

[*1]W_xuexing@163.com; [2]L_shuguang@yahoo.com

Abstract

This paper firstly introduced the working principle, combination switch- composite mode and implementation method, and designs the hardware system without power compensation by capacitor compound throw switch. According to the contactor and power electronic devices have problem in low voltage compensation of reactive power independent problems in application, Design of a capacitor switching composite switch it in order to PIC As the core and the thyristor and magnetic latching relay parallel main loop, it can realize fault diagnosis, recovery and indication function.

Keywords

Reactive Power Composition; Thyristor; Composite-switch; Magnetic Latching Relay

Introduction

Because transmission of reactive power in electric network can lead to network loss and a reduction in the voltage of the electric, so a lot of reactive power in power grid transmission must make electricity utilization rate is greatly reduced and seriously affect the quality of power supply, It not only has a harmful effect on the power generation, power supply and power distribution, but also affect the system running stability and economy. It is the essential means to meet the demand of power grid reactive power, which Compensation devices of reactive power is in the appropriate location in the grid[1]. Parallelling capacitor is the method, which is adopted by reactive power compensation, but it will produce the inrush current and harmonic if you parallel the capacitor do not have a good time, So the intelligent composite-switch[2]is the important device to solve this problem. The intelligent composite-switch make full use of the advantages, which is Power electronic devices in the open and shut off under control and Without the arc and Small magnetic keep contacts of relay contact resistance and no loss. Its the basic principle is that when both the sides of switch voltage is zero from zero passage trigger conduction thyristor trigger circuit close the brake, and pull in the magnetic hold relay, after the Magnetic stick relay contacts closed and removal of thyristor trigger signal, thus complete flow capacitance for free. First inflicts on thyristor trigger signal in the brake process, and then breaking magnetic hold relay, finally remove thyristor trigger signal, the thyristor to complete brake process in the current zero and capacitor dropped out of the running. Switched the capacitor when voltage is zero at both ends of switch, so that it does produce flow. It is no arc process when magnetic relay contact current transferred to thyristor In open circuit at the process, Because the switch opened dose not have arc and contact burning loss, which ensure intelligent compound switch has a long electrical life..

Principle of Intelligent Composite-Switch

Inductive load absorb reactive power in power grid, which reduce its output efficiency, we compensate power factor through the method is that parallel capacitor load at both ends. Assumes that the circuit can be as a standard sine wave voltage and current, The voltage and current are u and i, The compensation current is I_1, after compensating current of I, The power factor from $\cos\phi$ Increased to $\cos\phi_1$, Can be used to determine the required shunt capacitance calculation formula of C[3]:

$$u = \sqrt{2}U \sin \omega t \qquad (1)$$

$$i = \sqrt{2}\sin(\omega t - \phi) = \sqrt{2}\sin\omega t \cos\phi - \sqrt{2}\cos\omega t \sin\phi = i_p + i_q \qquad (2)$$

Circuit of active power P as follows:

$$P = (1/T)\int_0^T uidt = (1/T)\int_0^T \left(ui_p + ui_q\right)dt$$

$$= (1/2\pi)\int_0^{2\pi} UI\cos\phi(1-\cos 2\omega t)d(\omega t) +$$

$$(1/2\pi)\int_0^{2\pi} \left(-UI\sin\phi\sin 2\omega t\right)d(\omega t)$$

$$= UI\cos\phi \qquad (3)$$

Circuit reactive power is defined as:

$$Q = UI\sin\phi \qquad (4)$$

$$I_1\cos\phi_1 = I\cos\phi = U/I \qquad (5)$$

Current flowing through the capacitor:

$$I_c = I_1\sin\phi_1 - I\sin\phi$$
$$= (p/u)(\tan\phi_1 - \tan\phi) = \omega CU \qquad (6)$$

$$C = \left(P/(\omega U^2)\right)(\tan\phi_1 - \tan\phi) \qquad (7)$$

An Essential Part of Main Circuit

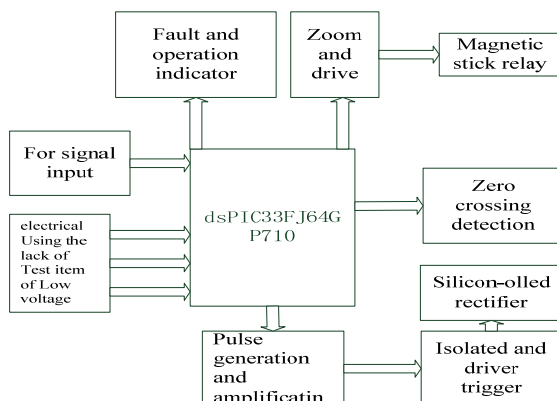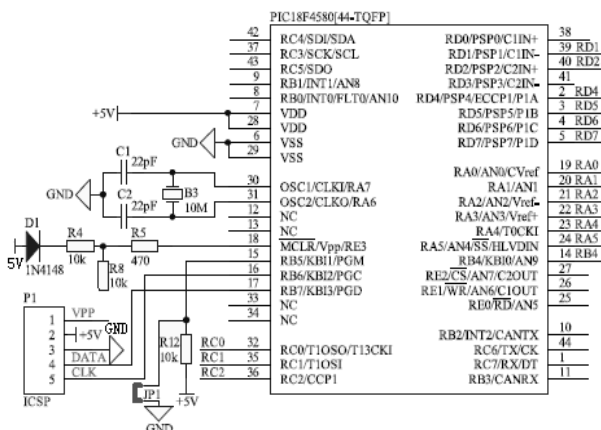FIG.1 CIRCUIT DIAGRAM

FIG. 2 MINIMUM SYSTEM OF SINGLE CHIP MICROCOMPUTER

Structure diagram as shown in figure 1，Microchip PIC

series microcontroller dsPIC33FJ64GP710 is the master control chip, which has a very high performance such as high speed, high anti-interference, stable performance, driving, low power consumption and so on. This system to accomplish many functions which is the voltage detection and phase detection, zero passage detection, operation instructions, and to keep magnetic relay and thyristor drive control.

When the microcontroller receives the appeal to signal through the contact voltage zero cross

detection, as shown in fig.3, the zero-crossing detection circuit is Single-phase ac signal[4],which According to the voltage of the voltage comparator two input values is that turn the sine signal into a square wave signal, So as to realize the function of zero crossing detection. The circuit comprises by the transformer TRANS, diode D_1, voltage comparator LM393, optical coupling PC817, capacitor C_1 and five resistors. the power of LM393 adopt to one power supply and terminal 5V DC voltage An input end of the optical coupler PC817 pull-up resistor R_4 is connected to 5V DC voltage, another input end is connected to the output terminal of the voltage comparator, an output end is grounded, another output end of the pull-up resistor R_5 is connected to 5V DC voltage, and the signal Uo to be detected from the port. It through the single-chip microcomputer to control pulse and the isolation amplifier and in the zero-crossing triggering thyristor conduction, and then through the intelligent judgment to make magnetic latching relay closed to realize capacitor, after capacitance in the portfolio, most of the current flows through the magnetic latching relay contacts, to achieve zero power consumption (pure silicon controlled rectifier conduction loss of tens to hundreds of Watts); when the SCM receives to signal is removed, the first trigger pulse to conduct thyristor, and then disconnect relay, the last stop pulse to cut the thyristor off automatically at the current zero.
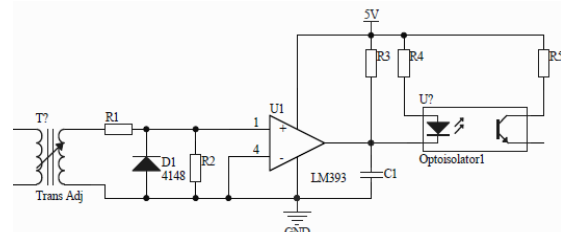

FIG. 3 ZERO PASSAGE DETECTION CIRCUIT

Fig.4 is the schematic circuit of trigger circuit T and silicon controlled magnetic relay K, wherein BL8023 is a two-way relay drive integrated circuit which is used to control the relay operating magnetic, It has some

characteristics that is large output current and low static power consumption，it can be used in the smart meter production industry and other use of this kind of relay industry widely MOC3081 as the SCR trigger circuit of integrated chip.
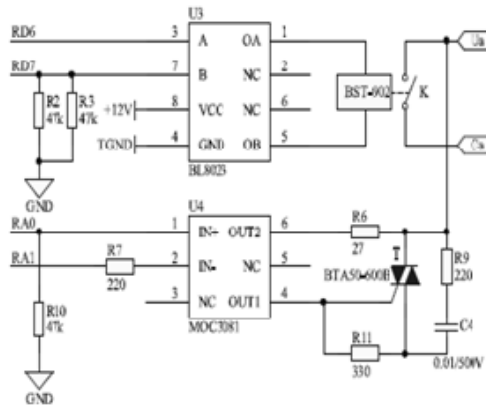

FIG. 4 PRINCIPLE DIAGRAM OF HARDWARE CIRCUIT

Fig.5 is the simulation waveform of composite switch[5]. The graph (5a) is that voltage waveforms at the two ends of the composite switch, graph (5b) is that composite switch ends of the output current waveform and figure (5c) is that the control of composite switch turn-on and turn-off of the on-off timing diagram. From Fig.5, the brake process for current zero-crossing points after the voltage across the capacitor to maintain supply voltage peak, so in the compound switch ends of maximum voltage is two times of the power peak voltage, Therefore, the voltage waveform simulation To provide the reference for thyristor voltage selection, magnetic relays and other components also it to ensure the reliable work of composite switch.
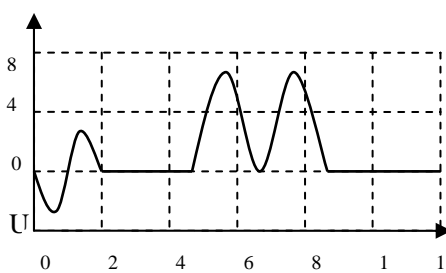
a) VOLTAGE WAVEFORM
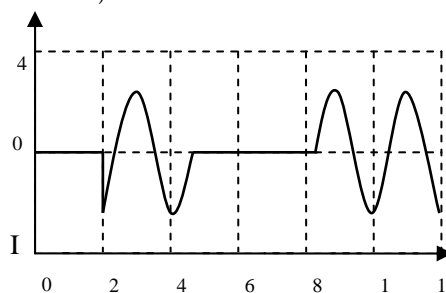
b) THE CURRENT WAVEFORM
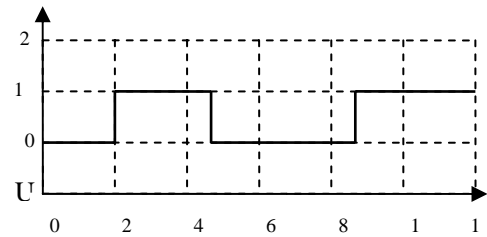
c) SWITCH ON-OFF TIMING DIAGRAM

FIG. 5 VOLTAGE ZERO SWITCHING AND ZERO CURRENT SWITCHING

The Software Design

Fig.6 is control circuit and software flow chart. The Procedures of Workflow is that To determine whether the switching signal input, when it does not receive switching signal it will enters the interrupt program part; if not it will enter the main part of program, it control the compensation loop closing and opening by the thyristor and magnetic latching relay. At first Main program completed initialization for voltage, phase sequence and flag, and then to determine whether the switching signal and switch state, according the switching signal to cast or cut operation. when the system occur faults it will automatic repair the faults at first, If it Unable to automatically repair switch refuses to vote and so the indication, so as to form a closed control loop.
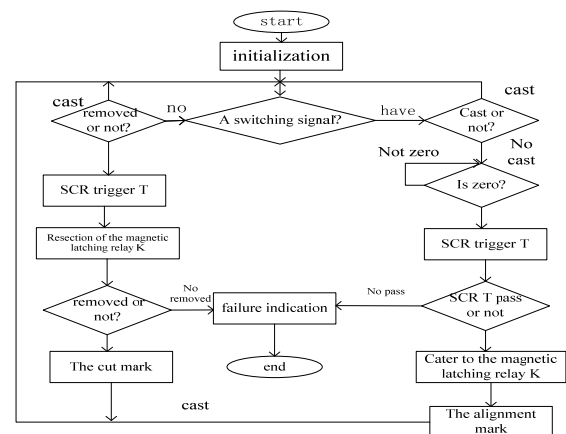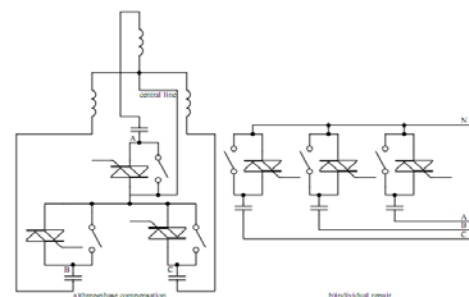

FIG. 6 SOFTWARE FLOW CHART

FIG. 7 WIRING DIAGRAM OF COMPOSITE-SWITCH

Application of Composite-Switch In Low Voltage Reactive Power Compension

According to the idle compensation method, Composite-switch connect with the a capacitor have two method is that the compensation switch and a complementary, Total compensation switch apply to switching three-phase capacitor, namely delta connection capacitor power supply usually consists of the same two winding transformer connected into a triangular; sub-fill switch for switching single-phase capacitor, is used in the Y connection, .the schematic diagram shown in fig.7.

TABLE 1 COMPOSITE SWITCH DATA

I_{CN}/A	U_{CN}/KV	I_P/A	U_P/V	U_I/V
20	0.25	17.0	227.0	387.0
20	0.25	17.1	228.1	391.1
20	0.25	17.1	228.6	391.3
26.7	0.25	23.2	228.3	391.2
26.7	0.25	22.1	226.7	386.4
26.7	0.25	22.6	227.4	389.5

Note:I_{CN} is capacitor rated current ,U_{CN} is capacitor rated voltage,$I_P$is single phase current, U_P /$U_I$is phase/line voltage

In order to verify the reliability of the composite switch, experiment adopt to self-healing low-voltage shunt capacitor, the experimental data are shown in tab.1. Heat from Microtek thyristor circuit is a small, the system run safely and reliably, the experiment result proves that the circuit works well and achieve switching requirements.

REFERENCES

Chunxi Zhao,Keming Zhao. "Grid monitoring wattless compensation device and a new generation of capacitor switching device-- Composite-switch". power equipment, 2005, (6): 125-125.

Di Wu. "Research and Realization of multifunctional low voltage reactive power compensation device". North China Electric Power University, 2004，12(2)：760-864.

He Jiang,Gongxiang Wu,Li'an Chen,Peiming Zhang. "Simulation study of wattless compensation device switching process". Journal of Fuzhou University: Natural Science Edition, 2007，35(6)：863-870.

Jinyun Zhao,Dawei Qin. "Design of electromechanical integration composite switch". Technology of electrical engineering, 2006, (11): 69-70.

Yejie Ren,Yulin Zhao. "Study on the comprehensive automation device for low-voltage power grid with reactive power compensation and other functions". Journal of Northeast Agricultural University, 2007, 38 (2): 229-231.

Yurong Nan. "Composite switch based on single chip microcomputer and its application in the low-voltage reactive power compensation in no". Modern electronic technology, 2004, (15): 84-86.